Introduction

1.1.Physical Environment

1.1.1. Physical Description

Mumbai stakes its claim as the biggest metropolitan city in India in terms of population size and economy it generates. Located in the western coast facing the Arabian Sea (Figure 1), the city, which serves as an important seaport and trade hub, is also the financial nerve-centre of the country. This capital city of the state of Maharashtra was once made up of seven small islands, which over the centuries got connected through natural and man-made land reclamations. Today, it is a narrow strip of island that abuts the coastal belt of Konkan,

Figure 1: Greater Mumbai Location Map

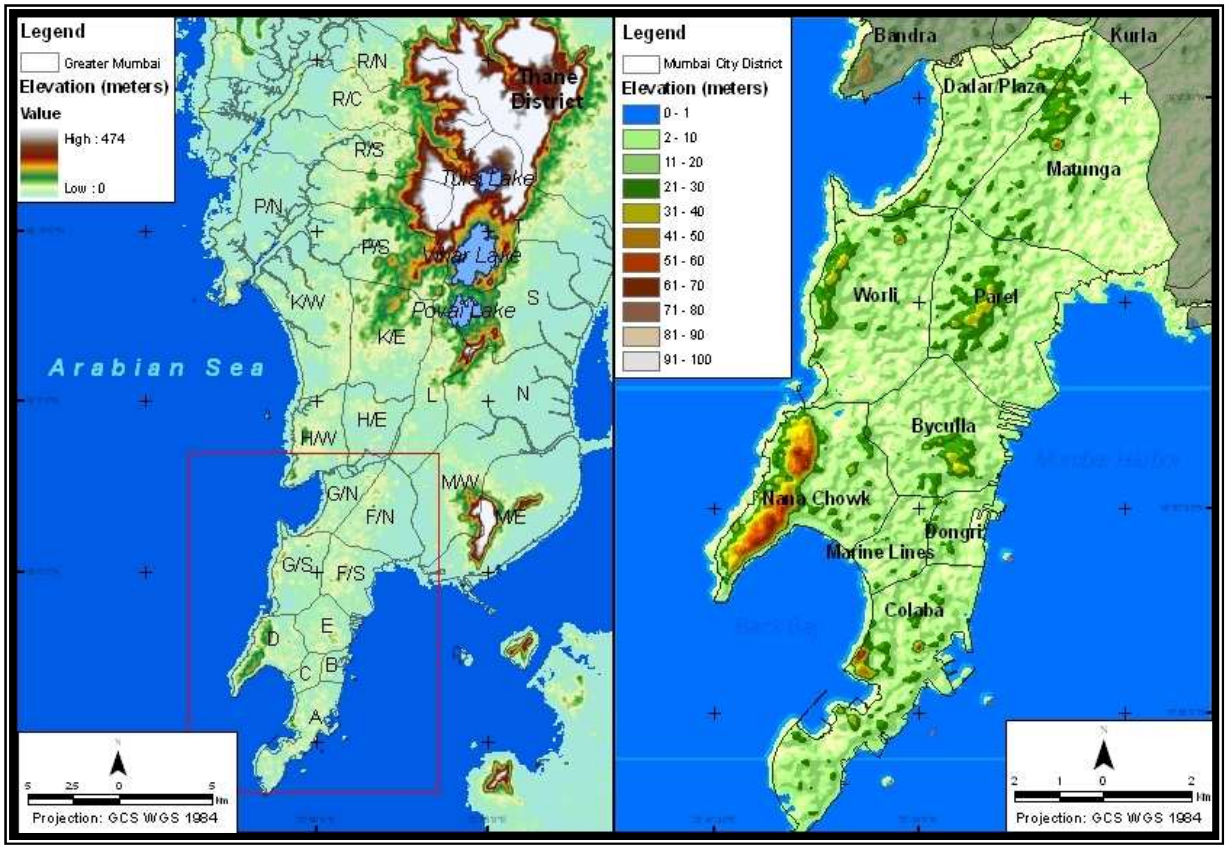
Sources: Center for Disease Control and Prevention; Census Info India 2001

1.1.2. Location

Mumbai is located in the western seaboard of India at coordinates 18.96° North 72.82° East. A major part of Mumbai sits on the old island of Salsette which lies at the mouth of Ulhas River. Usually, Mumbai is referred to as three different geographic entities: Mumbai City, Greater Mumbai, and Mumbai Metropolitan Region (Figure 2). Mumbai City is the core of the old port city of Mumbai during the colonial period. Since then, its territory has expanded northward to cover the suburbs and extended suburbs. The Mumbai Island City plus the Mumbai Suburban District comprise what is now called as Greater Mumbai. It is under the political administration of the Municipal Corporation of Greater Mumbai (MCGM, formerly

Bombay Municipal Corporation or BMC). The Mumbai Metropolitan Region was formed to create the urban agglomeration consisting of 7 Municipal Corporations and 13 Municipal Councils. In addition to MCGM, it includes the Municipal Corporations of Navi Mumbai, Mira-Bhayandar, Thane, Kalyan-Dombivali, Bhiwandi-Nizampur and Ulhasnagar.

Figure 2: Greater Mumbai and Mumbai City District



The Maps show the composition of Greater Mumbai namely, Mumbai Suburban District and Mumbai City (District).

Sources: ASTER GDEM, Google Earth, Praja.org, and EMI

1.1.3. Land Area

Greater Mumbai, the area under the administration of Brihanmumbai Municipal Corporation (BMC), spans a total area of 437.71 square kilometers (169 square miles). Mumbai Island City located at the southern tip of Mumbai covers 67.79 square kilometers (26 square miles) of land territory while the suburban district located north of the Island City covers 369 square kilometers (142.47 square miles) of land. Greater Mumbai accounts for most of Mumbai's territory. Mumbai, as an urban entity however, spans a bigger total area of 603.4 square kilometers (233 square miles) including some regions such as Defence lands, Mumbai Port Trust lands, and the Borivali National Park area, which are outside the administrative jurisdiction of MCGM. The bigger Mumbai Metropolitan Region covers an extensive area of about 4,355 square kilometers (1,681 square miles). (Mumbai on the net, 2010)

Table 1: Total Land Area

Units	Administrative Coverage	Land Area (Sq. Km.)	Land Area (Sq. Mi.)
Mumbai City	(1) Mumbai Island City District only	68.71	26.53
Mumbai Suburbs and Extended Suburbs	(2) Mumbai Suburban District only	369.00	142.47
Greater Mumbai (Under MCGM)	(1) + (2) Mumbai City and Mumbai Suburban Districts Greater Mumbai extends from Colaba in the south to Mulund, Mankhurd, and Dahisar in the north, and is under the jurisdiction of MCGM. Greater Mumbai forms two districts of Maharashtra, each under the jurisdiction of a District Collector. The Collectors are in charge of property records and revenue collection for the Central Government, and oversee the national elections held in the city.	437.71	169.00
Mumbai Urban Region	(1) + (2) + (3) Mumbai City and Mumbai Suburban Districts plus contiguous areas outside the jurisdiction of MCGM Areas (national parks, defence lands, Mumbai port trust, etc.)	603.40	233.00
Mumbai Metropolitan Region	(1) + (2) + (3) + (4) + (5) Greater Mumbai, Urban Region plus (4) Thane District and (5) Raigad District The Mumbai Metropolitan Region consists of 7 Municipal Corporations and 13 Municipal Councils. In addition to MCGM, it includes the Municipal Corporations of Navi Mumbai, Mira-Bhayandar, Thane, Kalyan-Dombivali, Bhiwandi-Nizampur and Ulhasnagar	4,355.00	1,681.00

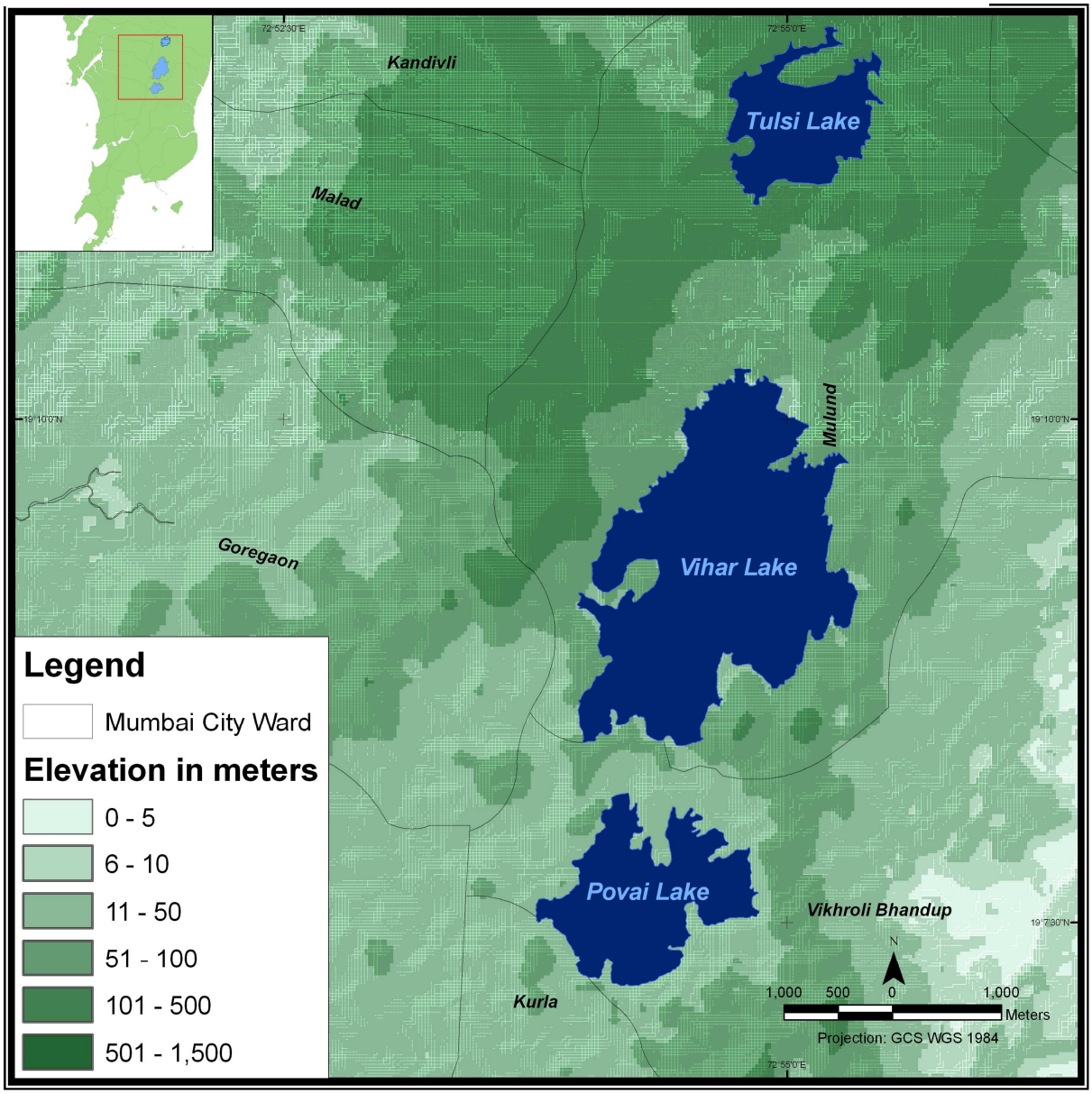
1.1.4. Elevation

Many parts of the city lie just above sea level, with elevations ranging from 10 meters (33 feet) to 15 meters (49 feet). The city has an average elevation of 14 meters (46 feet). Northern Mumbai (Salsette) has a hilly while the rest of the city is low lying and flat. The highest point in the city is 450 meters (1,476 feet) located in Salsette north of Mumbai in the Powai-Kanheri ranges. (Mumbai on the net, 2010)

1.1.5. Soil

The soil cover in the city is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants dating back to the late Cretaceous and early Eocene eras. Mumbai sits on a seismically active zone owing to the presence of 23 fault lines in the vicinity. The area is classified as a Seismic Zone III region, which means an earthquake of up to magnitude 6.5 on the Richter-scale.

Figure 3: Lakes in Greater Mumbai



Sources: ASTER GDEM, Google Earth, Praja.org, and EMI

1.1.6. Bodies of Water

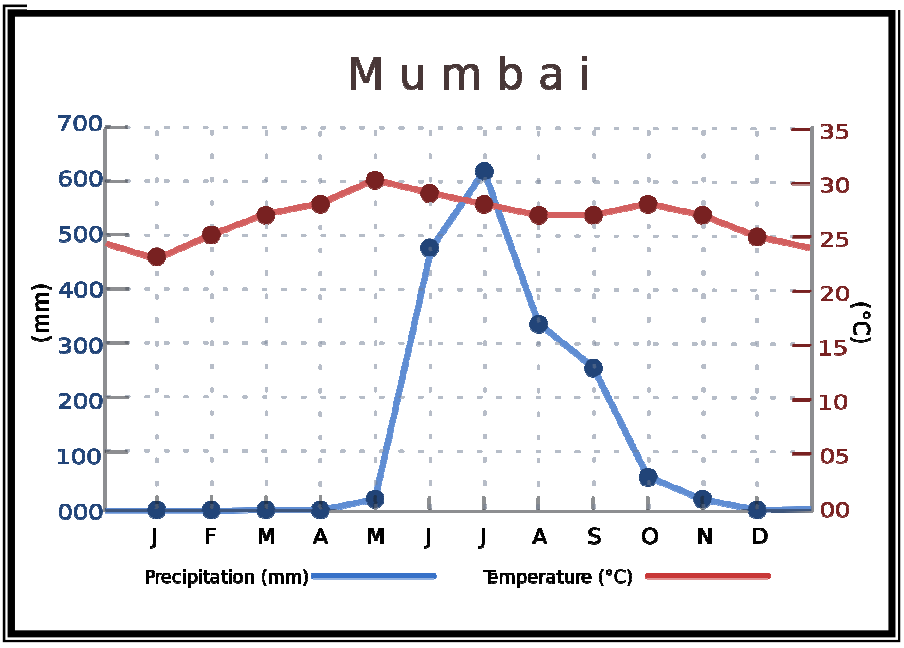
Three lakes are located within the metropolitan limits - the Tulsi Lake, Vihar Lake and the Powai Lake (Figure 3). The first two are located within the Borivali National Park and supply part of the city's drinking water. Other lakes that supply water to the city include Lower Vaitarna, Upper Vaitarna and Tansa Lake. Mumbai also has three small rivers within the city limits -- the Dahisar River, Poinsar (or Poisar) and Ohiwara (or Oshiwara), originating in the National Park. The polluted Mithi River originates from Tulsi Lake and gathers water overflowing from Vihar and Powai Lakes. The coastline of the city is indented with numerous creeks and bays stretching from Thane creek on the eastern to Madh Marve on the western front. The eastern coast of Salsette Island is covered with large mangrove swamps, rich in biodiversity, while the western coast is mostly sandy and rocky.

1.1.7. Climate

Mumbai has a tropical wet and dry climate under the Köppen climate classification. The city does not experience distinct seasons, but the climate can broadly be classified into two main seasons—the humid season and the dry season. Usually, the period between October to May is relatively dry. The city gets southwest monsoon rains beginning June to end September with peak rains occurring in July. Occasionally, northeast monsoon showers occur in October and November. The maximum annual rainfall ever recorded was 3,452 millimeters (135.9 in) in 1954. The highest rainfall recorded in a single day was 944 millimeters (37.17 inches) on 26 July 2005. The average total annual rainfall is 146.6 millimeters (84.51 inches) in the Island City, and 2,457 millimeters (96.73 inches) in the suburbs. (Mumbai on the net, 2010)

The average annual temperature is 27.2 °C (81.0 °F) and the average annual precipitation is 16.7 centimeters (85.31 inches). Figure 4 shows the historical average of monthly precipitation and temperature in Mumbai. In the Island City, the average maximum temperature is 31.2 °C (88.2 °F), while the average minimum temperature is 23.7 °C (74.7 °F). In the suburbs, the daily mean maximum temperature range from 29.1 °C (84.4 °F) to 33.3 °C (91.9 °F), while the daily mean minimum temperature ranges from 16.3 °C (61.3 °F) to 26.2 °C (79.2 °F). The record high is 40.2 °C (104.4 °F) on 28 March 1982, and the record low is 7.4 °C (45.3 °F) on 27 January 1962. (Mumbai on the net, 2010)

Figure 4: Monthly Precipitation and Temperature in Mumbai



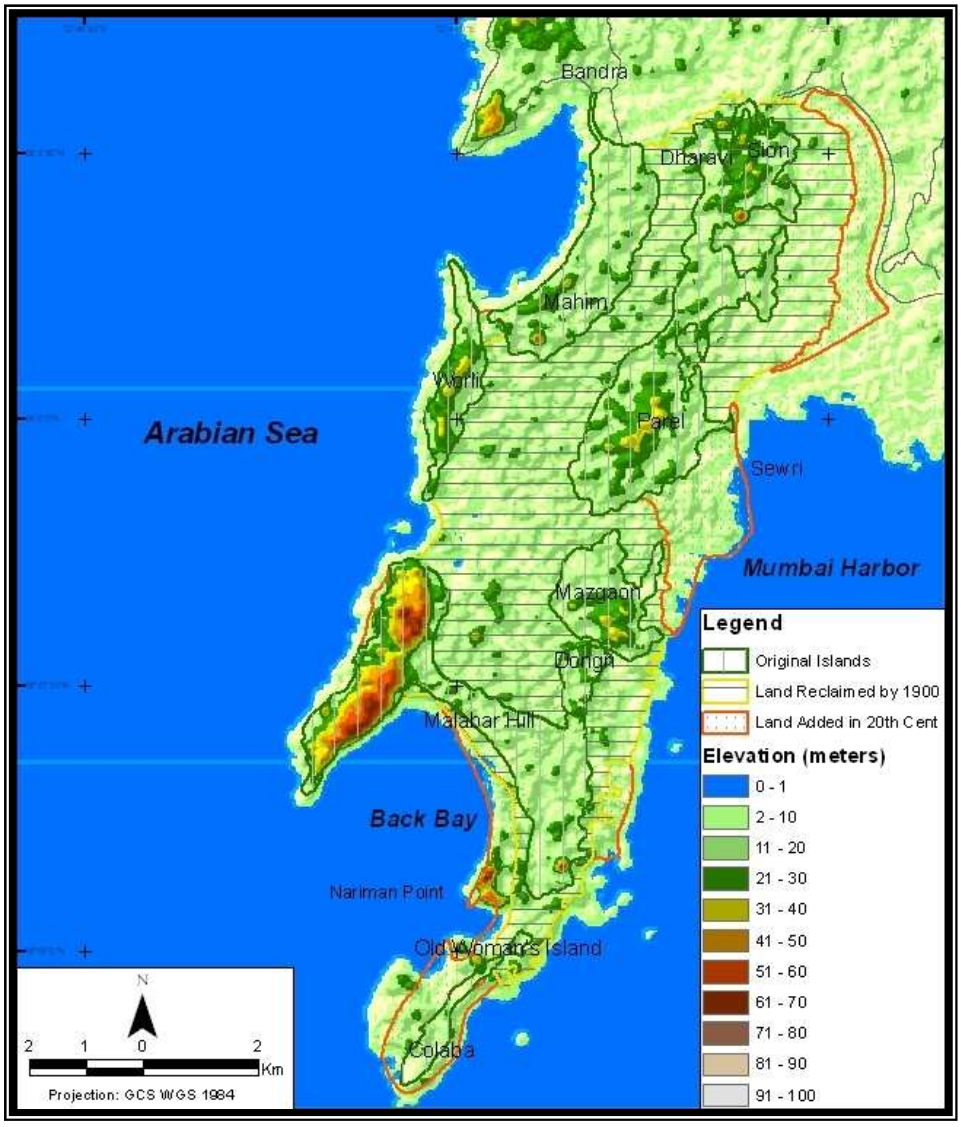
Source: *Indian Meteorological Department* at http://www.imd.ernet.in/section/climate/mumbai1.htm

1.2.History of Mumbai

1.2.1. The Island Group

Greater Mumbai (BrihanMumbai), before it became known today as among the busiest and populated cities in the world, was just an agglomeration of seven islands separated by shallow sea during the Stone Age (Greater Bombay District Gazetteer, 1986). These seven islands in their anglicized names were: Colaba and Little Colaba which was located in the present day Colaba and Nariman Point, Bombay Island which was the backbone of the City of Mumbai, Mozagaon and Parel which were located on the eastern strip, Worli on its western strip and Mahim on the northwestern strip. In 150 AD, Ptolemy, a Greek geographer called this area *Heptanesia*, meaning, cluster of seven islands (Da Cunha 1993). In the passage of time, these hilly islands were later joined together by reclamation projects and further extended beyond their respective island boundaries (Mumbai.org, 2009).

Figure 5: The Original Seven Islands of Mumbai City and Subsequent Physical Growth



Sources: ASTER GDEM, Google Earth, and EMI

1.2.2. Pre-colonial Peroid

The early residents of these islands were fishermen known as Kolis. Their ancestors have a long standing trade with ancient Egypt and Persia. They were later integrated to the Maurya Empire in the third century BC under the Buddhist Emperor Ashoka of Magadha (Ring, Salkin and Boda, 1994).

After the Maurya Empire, successive dynasties ruled Mumbai starting with the Shatavahana dynasty (Ring, Salkin and Boda, 1994). This was the period when overseas trade with the Southeast Asians and the Roman Empire grew significantly (Keay, 2000). In 1348, the islands were under the possession of the leaders of Gujarat and later from 1391 to 1534 under the supervision of the Gujarat Sultanate (Prinsep, Thomas & Henry 1858).

1.2.3. Dawn of the Colonial Period

In 1508, a group of Portuguese sailors led by Francisco de Almeida built a small fort in one of the islands which they called *Bon Bahia* (Keay, 2000) or "fine bay" (Mumbai.org, 2009) or its anglicized counterpart—Bombay. They later acquired the seven islands (Bombay included) and other territories in 1534 through a treaty with the Gujarat Sultanate (Da Cunha 1993).

On May 11, 1661, the islands were handed over in dowry to Charles II, ruler of England, Scotland and Ireland, as a dowry to his marriage with Catherine of Braganza, daughter of John IV, King of Portugal (Miller 1991). This was part of a wider Anglo-Portuguese alliance against their Dutch rivals (Keay, 2000). The British Crown transferred the administration of the islands to the British East India Company in 1668 (Da Cunha 1993). Due to bureaucratic convenience, Bombay was described as part of the County of Kent and leased for 10 British pounds (Keay, 2000).

1.2.4. Reclamation Project

The merging of seven islands into a single landmass would come in the later part of the British rule. Travelling between the islands led to loses of life among commuters especially during the monsoons. These circumstances paved the way for a series of reclamation activities (Mumbai on the net, 2010). Early efforts in the eighteenth century were focused on filling small creeks crossing the northern Flats of Bombay Island (Mumbai Pages, 2010). The first major civil engineering project aimed at connecting the islands took root in 1782 amidst the rejection of the plan from the Directors of the British East India Company (Duff 1921). Mr William Hornby was the Governor then. Dubbed as the Hornby *Vellard* or embankment, the project, completed in 1784, allowed the reclamation of the Flats. It provided an additional 400 acres of land for the extension of the crowded inner city (Mumbai Pages, 2010) by blocking the Worli creek and preventing the low-lying areas of Bombay from being flooded at high tide (S. Dwivedi and R. Mehrotra, 1995).

Several reclamation projects were initiated subsequently such as the causeway at Sion in 1802. It connected Bombay with Salsette (Thana District Gazetteer, 1984). However, the islands were unified into one landmass only after the Colaba island was joined with Bombay in 1838 and the Causeway connecting Mahim and Bandra was completed in 1845 (Mumbai Pages, 2010). Reclamation continued almost till a century-and-half later as the area of Bombay expanded in hundreds of acres of land. It was halted only by the Supreme Court in 1990 with the setting up of Coastal Regulatory Zones (Mumbai Pages, 2010).

1.2.5. Rise of Mass Transportation

Among the beneficiaries of the reclamation projects were the railway companies. In 1853, the Great Indian Peninsular (GIP) Railway Company servicing Thane and Bombay was inaugurated. Soon, the Bombay Baroda and Central Indian Railway Company (BB&CI) began servicing in Bombay, linking it with other destinations. Tramways were also introduced in the same period. (Mumbai Pages, 2010)

Figure 6: Mass Transportation in Mumbai

Today, mass transportation has been made possible in Mumbai through the reclamation projects. It has enabled Mumbai Central Station to be one of the major hubs for travel to other parts of the State and country.

Source: "Flickr: Siraj Fastrack" at http://www.flickr.com/photos/23727908@N04/4034237720/

1.2.6. Communication within the Continent and Overseas

Communication took a big leap forward in Bombay in the mid-19th century. The first telegraph line was laid between Bombay and Calcutta in 1852. Within the next decade, additional lines were completed, connecting Bombay not only with the rest of the country but also with Europe and the Middle East. And in 1870, communication lines reached London through an underwater cable. (Mumbai Pages, 2010)

1.2.7. Water Supply System

In 1860, water was supplied to Bombay through pipelines (Figure 7) from the Tulsi and Vihar lakes. With assured large reservoirs of water, open wells were sealed and banned since they were potential breeding grounds for mosquitoes. This reform was met with superstitious opposition, but was implemented nevertheless. Years later, the same wells provided non-potable water to supplement the water supply from the lakes whenever monsoon failed to provide sufficient water in their catchment areas. Alongside the water supply system, a good drainage system was also constructed. (Mumbai on the net, 2010)

Figure 7: Water Pipes

Pipes like this carry water with a consumption of 3,900 million liters a day (2004 figure). As of 2004, Tulsi and Vihar lakes only provide 128 million liters a day (2004 figure).

Source: "Flickr: Shutter Butter" at http://www.flickr.com/photos/shutter_butter/2827137461/

1.2.8. Reverting of Control to the British Government

Amidst heavy infrastructural development at that time, the administration of India reverted from the Company to the Crown due to accusations of mismanagement in the part of the Company (Mumbai on the net, 2010). In 1858, the British Crown took control of India and the British East India Company was finally dissolved in 1874 (www.indhistory.com)

1.2.9. Economic Boom and the Creation of BMC, BEST and BPT

The economy rose significantly during the American Civil War. An offshoot was Bombay became the world's chief cotton trading market (Greater Bombay District Gazetteer 1986). With the opening of the Suez Canal, the creation of the Bombay Port Trust (BPT) became imperative. Thus, the BPT, created in 1870, gave Bombay the status of being one of the largest seaports on the Arabian Sea (www.indianexpress.com).

The economic boom and the shifting of administration led to the creation of two key institutions in Bombay, namely, Bombay Municipal Corporation (BMC) and the Bombay Electric Supply and Transport (BEST). BMC was established in 1882, to provide a modern framework of governance for the rapidly-growing city (Dwivedi and Mehrotra, 1995). And in 1888, the Bombay Municipal Act, brought into force, vested the Crown with more powers to interfere in civic matters (The Mumbai Municipal Corporation Act 1888). Today, Brihanmumbai Municipal Corporation or the Municipal Corporation of Greater Mumbai (MCGM) is one of the largest local governments in the Asian continent. (www.mcgm.gov.in)).

1.2.10. Economic Down-turn Due to the Plague

Bombay's commercial growth and expansion of land area witnessed tens of thousands of people migrating to the city. This development was not without its pitfalls. Along with the urbanization came the calamities. In 1896, an outbreak of bubonic plague killed an estimated 1,900 people every week. 850,000 people -- more than the total population of 1891 – fled Bombay in panic. Among the other fallouts was the decline and recession in the textile industry (Mumbai Pages, 2010). The killer plague was indirectly responsible for the creation of the Bombay City Improvement Trust. The Trust came out with the first suburban plan to ease population congestion (Greater Bombay District Gazetteer 1986,).

1.2.11. Landmarks

After the Victoria Terminus, Crawford Market and the Bombay High Court were built in the mid to the late 19th century. The early 20th century Bombay saw the construction of other landmarks in Mumbai such as the General Post Office, the Prince of Wales Museum (Chhatrapati Shivaji Maharaj Vastu Sangrahalaya) and the Gateway of India. The Gateway was used as the send-off point of the remaining Crown officials during the independence in 1947. (Mumbai.org, 2010)

1.2.12. Independence

Before the country attained independence on August 15, 1947, Bombay witnessed the rise of the Indian National Congress, the non-violent civil disobedience and Quit India campaigns. The architect of these movements, Mahatma Gandhi, was its frequent visitor (Lonely planet, 2010). Soon after independence, Bombay also witnessed a change in its territorial make-up. Bombay was declared the capital of Bombay State. Three years later, the Greater Bombay District was created as a merger of the Bombay Suburbs and the city of Bombay (www. mumbaisuburban.gov.in). In 1960, there was a reorganization of the states. The Bombay State was divided along linguistic lines into State of Gujarat and State of Maharashtra, with the latter having Bombay as its capital (Keay, 2000). To plan and coordinate development not only with Bombay, but also the rapidly growing neighboring local government units, the Bombay Metropolitan Region Development Authority was established in 1975 under the auspices of the State of Maharashtra (MMRDA, 2010). In 1995, Bombay was renamed Mumbai after the Koli stone goddess Mumbadevi.

1.2.13. Terrorism and Natural Calamities

The 21st century Greater Mumbai witnessed the phenomenon of terrorism. Terror attacks in 2002, 2003 and 2006 involved bombing of transport services and crowded areas. 2003 registered the most number of attacks, while the July 2006 bombing had the most number of casualties. The worst attacks took place between November 26-29, 2008, killing at least 166 people of 17 nationalities (www.latimes.com). The City's historical landmarks too suffered damages.

Mumbai also bore the brunt of the worst flood (Figure 8) fury on 26 July 2005 when it was lashed by a record 39 inches of rain within 24 hours, 25 inches in just 12 hours. The rain water caused the sewerage system to overflow, resulting in the contamination of all water lines (www.bbc.co.uk). Over 700 flights had to be cancelled or delayed due to heavy flooding and poor visibility. The railway network stood paralyzed and telephony services were majorly disrupted (mdmu.maharashtra.gov.in).

Figure 8: 2005 Flood

The 2005 flood wrecked havoc on the streets of Mumbai as pedestrians and commuters vie for the remaining space that was not engulfed with much water.
Source: "Flickr: Sebastian fotos" at http://www.flickr.com/photos/mumbaiwalla/500651434/